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January 18, 2005

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PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2).

Docket Number		Type a plus sign (+) inside this box ☐	+
697001			

INVENTOR(s)/APPLICANT(s)

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TITLE OF THE INVENTION (280 characters max)

SUB-AMPLE THE CONTENT TO IMPROVE AVERAGE COLOR EXTRACTION FOR CONTROLLING AMBIENT LIGHTING SYSTEMS

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ENCLOSED APPLICATION PARTS (check all that apply)

X	Specification	Number of Pages	4	☐	Small Entity Statement
☐	Drawing(s)	Number of Sheets	0	☐	Other (specify)

METHOD OF PAYMENT (check one)

		PROVISIONAL FILING FEE AMOUNT ($)	$160.00
☐	A check or money order is enclosed to cover the Provisional filing fees		
X	The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number: 14-1270		

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE: Gregory L. Thorne Date: 1/5/04

TYPED or PRINTED NAME: GREGORY L. THORNE

REGISTRATION NO.: 39,398

☐ Additional inventors are being named on separately numbered sheets attached hereto

CERTIFICATE OF EXPRESS MAILING

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I hereby certify that this paper and/or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to the Commissioner for Patent, Alexandria, VA 22313.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

SRINIVAS GUTTA ET AL

Atty. Docket

697001

Serial No.

Filed: CONCURRENTLY

Title: SUB-AMPLE THE CONTENT TO IMPROVE AVERAGE COLOR EXTRACTION FOR CONTROLLING AMBIENT LIGHTING SYSTEMS

Commissioner for Patents
Alexandria, VA 22313

APPOINTMENT OF ASSOCIATES

Sir:

The undersigned Attorney of Record hereby revokes all prior appointments (if any) of Associate Attorney(s) or Agent(s) in the above-captioned case and appoints:

GREGORY L. THORNE **(Registration No. 39,398)**
c/o U.S. PHILIPS CORPORATION, Intellectual Property Department, 580 White Plains Road, Tarrytown, New York 10591, his Associate Attorney(s)/Agent(s) with all the usual powers to prosecute the above-identified application and any division or continuation thereof, to make alterations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith.

ALL CORRESPONDENCE CONCERNING THIS APPLICATION AND THE LETTERS PATENT WHEN GRANTED SHOULD BE ADDRESSED TO THE UNDERSIGNED ATTORNEY OF RECORD.

Respectfully,

Michael E. Marion, Reg. 32,266
Attorney of Record

Dated at Tarrytown, New York
this 5th day of January, 2004.

Sub-sample the Content to improve Average Color Extraction for Controlling Ambient Lighting Systems

Current systems for automatic triggering of lights based on the content process each and every frame. Such an approach has two obvious disadvantages: (a) the computational load needed to do such processing becomes very large and thus leads to synchronization problems. In other words there is a delay between what is displayed on the screen and the triggered light effects and (b) processing of each and every frame leads to undesirable flickering due to subtle color changes in the content. These disadvantages were addressed by using subsampling, i.e. processing only one in N frames. So only for one in N frames, the actual LED colors are calculated and for the intermediate frames, the colors are linearly interpolated. This reduces flickering a lot and at the same time it makes the algorithm an order of N times faster.

The general steps that need to be followed to realize the invention are as follows:

1) Acquire a video signal and decode the video signal into a set of frames
2) Reduce frames by subsampling
3) Extract color information from the content (frames) around the boundary
4) Transform the color information of the content from the RGB space onto the color space of the LEDs and the displays color space.
5) Use linear interpolation to compute the color information for intermediate frames
6) Transmit the color output to the LED units so as to trigger them.

Steps (1) and (6) are straightforward and are not further discussed below.

The current setup for an ambient lighting system is as shown below:

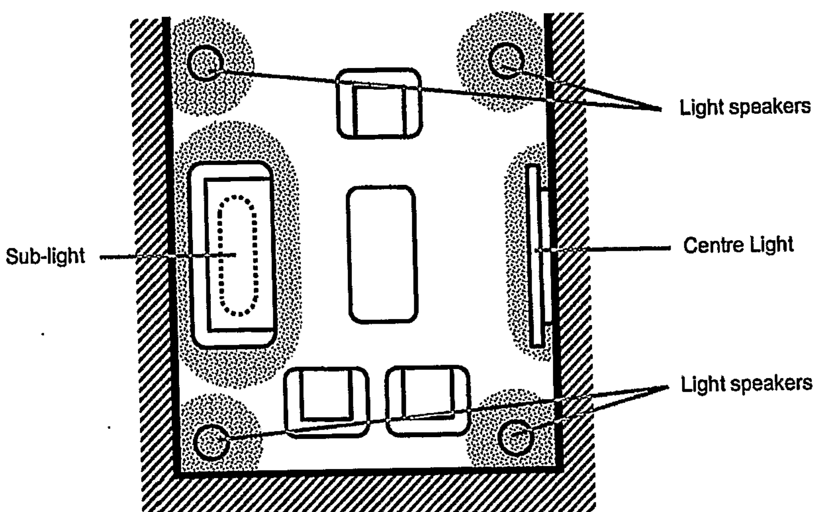

Figure 1. Setup of Light Units

In the above figure there are 11 independently controllable LED lighting units. There are four light speakers, one unit under the couch ('Sub-light') and 6 LED units on the center-light. The center-light is a little bit special, in the way it is set-up - it has 6 independently controlled, light units behind the four sides of the Flat TV and is shown below:

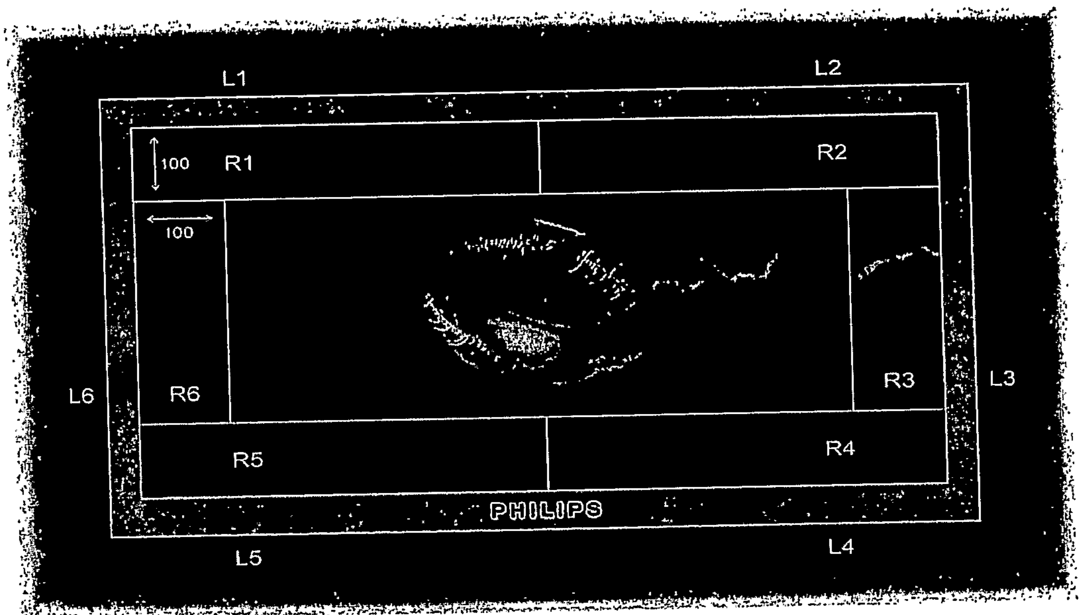

Figure 2: Setup of light units around the TV

In the above figure L1 to L6 refer to the light units around TV. The figure also shows a single frame of the content displayed on the TV. Each light unit located at the back of the TV is triggered by extracting the average color information from each region – R1 to R6. Each region has a width of 100 pixels. As an example if the size of the frame were 720x576 pixels, then the size of R1, R2, R4 and R5 would be 360x100 pixels. Similarly size of R3 and R6 would be 100x376 pixels.

Since the video signal is decoded into a set of frames (25 frames per second) in the RGB color space, the resulting image size would be 720x576x3 which is a 3D matrix where each 2D matrix of size 720x576 corresponds to each one of the Red, Green and Blue channels.

Before the color information could be extracted from the frames, first perform subsampling, i.e., process 1 in N frames. The optimal value has been found out to be 1 in 10 frames. Thus the computational load reduction would be by a factor of 10. Thus the extraction of color information would be started by processing the 1st frame followed by the 10th frame and so on.

The average color information in each frame for each region of the channel is extracted by summing up all the pixels in that region and dividing by the total number of pixels in that region for each channel. The equation for the extraction of the average color information for each region for one channel is shown below:

$$R_{red} = \frac{\sum_{i=1,j=1}^{n,m} M_{ij}}{n \times m}$$

If the region under consideration is R1, then M_{ij} is of size 360x100 with n equal to 360 and m equal to 100. The above equation gives us the average of all the pixels for the red channel. Thus the average color for particular region would now be a triplet,

$$R_{AVE} = \lfloor R_{red}, R_{green}, R_{blue} \rfloor$$

The same procedure is repeated for all the regions and for all the channels within each region.

Next in order to set the lights, a mapping transformation needs to be performed between the TV and light units. This is achieved via a standard set of equations that take as input the measured color primaries from each LED unit. The color primaries for the red, green, blue and the reference white color components are acquired by using a color spectrometer. Once the primaries are obtained, the transformation process is as follows:

(a) Given a set of chromaticity (red, green and blue primaries) co-ordinates and the reference white, compute the transformation matrix for mapping the average color information onto the XYZ color gamut space for both the FLAT TV as well as the LED units. This gives us two sets of equations :

$[X; Y; Z]=M_1 * [R;G;B]$ for Flat TV

$[X; Y; Z]=M_2 * [R';G'B']$ for LED's

(b) The mapped RGB values for the light units could be found by solving the following:

$$[R';G';B'] = M_2^{-1} * M_1 * [R;G;B]$$

In steps (a) above, [R; G; B] corresponds to the triplet which is nothing but the computed average color information for a particular region for all channels. The general method for computing the matrix M is shown below:

Given the chromaticity coordinates of an RGB system (x_r,y_r), (x_g,y_g) and (x_b,y_b) and the white point (x_w,y_w), the method to compute the 3 x 3 matrix for converting RGB to XYZ is as follows:

$[X\,Y\,Z] = [R\ G\ B][M]$

where

$$[M] = \begin{bmatrix} S_r X_r & S_r Y_r & S_r Z_r \\ S_g X_g & S_g Y_g & S_g Z_g \\ S_b X_b & S_b Y_b & S_b Z_{gb} \end{bmatrix}$$

$$\begin{array}{lll} X_r = x_r & Y_r = y_r & Z_r = 1 - (x_r + y_r) \\ X_g = x_g & Y_g = y_g & Z_g = 1 - (x_g + y_g) \\ X_b = x_b & Y_b = y_b & Z_b = 1 - (x_b + y_b) \\ X_w = x_w & Y_w = y_w & Z_w = 1 - (x_w + y_w) \end{array}$$

$$[S_r \quad S_g \quad S_b] = [X_w \quad Y_w \quad Z_w] \begin{bmatrix} X_r & Y_r & Z_r \\ X_g & Y_g & Z_g \\ X_b & Y_b & Z_b \end{bmatrix}^{-1}$$

The above method is used for obtaining M_1 and M_2 and [R' G' B'] by following step (b) above. Thus [R';G';B'] is the transformed color information for a particular region. The same process is repeated for obtaining [R' G' B'] for each of the 6 regions.

Once the color information has been extracted and transformed for the 1st and the 10th frame, then the color information for intermediate frames is computed by first computing the absolute difference between the 1st and the 10th frames divided by 10 herein after called as fractional difference. Thus the 2nd frames color information would be the color information of the 1st frame plus the fractional difference. Similarly the 3rd frames color information would be the 2nd frames color information plus the fractional difference and so on.

The color information is then sent to the light units so that they can be triggered. It is also important to note that the width of each region could be varied and the number of regions in the frame could also be varied. As an example, instead of using 6 regions, one could use only 4 regions as well. In such a case, the thresholded color information for the upper region could be sent to both the LED panels located at the top of the TV. Furthermore, the solution discussed above could be realized in software or via a programmable hardware platform such as EPLD, etc.